MANUAL

TO ACCOMPANY THE

LUNATELLUS GLOBE

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J. Davis

MANUAL

TO ACOMPANY THE

LUNATELLUS GLOBE,

CONTAINING A COMPLETE COURSE

—OF—

PROBLEMS AND ILLUSTRATIONS

OF THE

FUNDAMENTAL PRINCIPLES

—OF—

GEOGRAPHY AND ASTRONOMY,

FOR THE USE OF

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—BY—

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ALLEGHENY CITY, PA.

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PREFACE.

This Manual is a guide to the proper use of the Lunatellus Globe, which faithfully illustrates the principles of Geography and Planetary motion. The pupil's greatest difficulty in obtaining a correct knowledge of Mathematical Geography and Astronomy, often arises from previous false conceptions of their principles acquired sometimes with the use of imperfect Apparatus. This fact intruding itself so frequently in the Class-room, suggested the necessity of the Lunatellus Globe; which on account of its *convenience, accuracy and durability,* is rapidly filling a *vacuum* in Families and Schools. It contains three bodies, one of them being a *twelve inch Terrestrial Globe,* which by their relations and motions exhibit the natural relations and motions of the Sun, Earth and Moon. The body representing the Sun, is made to turn on its axis, while the Terrestrial Globe, having its axis properly inclined, has a similar motion, and at the same time revolves in its orbit around the Sun, showing his rising and setting, his Declination, or apparent motion North and South, the change of Seasons, the vicissitudes of Day and Night and their alternate increase and decrease in length. The body representing the Moon, is made to revolve around

the Earth in an elliptical orbit, whose plane is at an angle of about *five* degrees with the plane of the Ecliptic; also around the Sun and on her own axis, exhibiting her days and nights, changes, phases and fulling and the interesting phenomena of Solar and Lunar Eclipses. The principles of Geography and Astronomy and the phenomena resulting therefrom, being involved in the form and movements of this Apparatus, THE MANUAL contains a consecutive series of Problems and Examples based upon these principles whereby the pupil may have an accurate, and practical illustration of their meaning.

The Author while preparing this Manual, carefully consulted the best English, French and American Authorities on the use of Globes, with the view of having it simple, brief and at the same time sufficiently comprehensive for the purpose for which it is designed.

The Definitions and Explanations which relate to the subjects considered in this Manual are, for the sake of convenience placed after the Illustrations and Problems. And in connection with each of the Illustrations and Problems reference is given to such Definitions and Explanations as should be studied with care before entering upon its solution.

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Letters representing the principal parts of the Lunatellus Globe.

A, The Arm which carries the Earth and Moon.
F, The Semi-circle, representing the plane of the Ecliptic.
C, The Circle of Illumination. I, The Calendar Index.
H, The Hour Index, B, The Base.
Q, The Quadrant. S, The Sun.
M, The Moon. E, The Earth.
D, The Cap which carries the Sun.

Directions for putting the parts together.

1st. Place the rear end of the Arm A in the Cap D and tighten the screws in the Cap. Then revolve the gear in the Arm A with the fingers, till the central axis of the Globe over which we place its tubular axis, inclines directly towards the center of the Cap D.

2nd. Place the Cap D on the central part of the Base B, with the Arm A directly over the word Solstice, June 21st, and fasten the Cap, Arm and Base together with the bolt which contains a thumb nut.

3rd. Place the tubular axis of the Globe on its central axis which is carried by the Arm A, so that the gear on the upper end of the standard, fixed in the outer end of the Arm A and the gear connected with the South Pole of the Globe, will come together; observing at the same time to have the outer ends of the yoke extending from the South Pole equally distant from the center of the Cap D.

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4th. Place the Hour Index on the North end of the tubular axis of the Globe, and attach with a screw to the central axis of the Globe, the small metal bearing, containing a square hole in one end and a knob with a groove in it loosely pivoted in the other end; observing to incline the bearing in putting it on directly away from the center of the Sun when it is in place, and then put the inner edge of the Circle of Illumination in this groove, as it is being connected to the Instrument by the pivots of the yoke.

5th. Finally, place the Sun S with the Semi-circle F attached, at right angles with his Polar axis, on the center of the Cap D, and adjust the Moon Rod as the parts at the outer end of the Arm A suggest, and the Apparatus will be ready to operate.

LUNATELLUS GLOBE.

The Lunatellus Globe is the only *device in existence* which *faithfully* illustrates the mutual relations and various movements of the Sun, Earth and Moon. It is composed wholly of Iron Brass and Steel, except the *Terrestrial Globe* which represents the Earth, and the Chart that covers the Base.

BASE AND CHART.

The Base of the Instrument is cast in one piece and has placed upon it a Chart showing how the Sun, Earth and Moon perform their functions, as members of the Solar System, every day and hour in the Year.

The Chart contains in their proper relations, the Signs of the Zodiac, the months and days of the Year, the various lengths of the Seasons, the periods when the Sun is fast and slow, the degrees of Celestial Longitude, the Perihelion, Aphelion, Solstitial and Equinoctial points, together with other Symbols relating to the various movements of the Apparatus.

SUN AND SEMI-CIRCLE.

The Sun is represented by a body composed of Brass and connected by one of its Poles to the gearing within. To the Equator of this body is attached a Semi-circle which, when properly adjusted represents the Plane of the Ecliptic.

EARTH.

The Earth is represented by a *Terrestrial Globe, twelve inches in diameter,* and is pivoted by the South Pole to the gearing which gives it rotary motion.

MOON.

The Moon is represented by a Globe relative in size to that of the Terrestrial Globe, and is attached at one of its Poles to the outer end of a bent rod, the inner end of which is loosely pivoted to an upright placed on a disk which revolves, carrying the Moon around the Earth and and causing her to cross and recross the plane of the Ecliptic at an angle of about 5 degrees, as both Earth and Moon revolve around the Sun.

CIRCLE OF ILLUMINATION.

The Circle of Illumination is a flat Metallic Ring surrounding the Globe and loosely pivoted in the plane of the Equator, so that it is at liberty to change its position *every moment* as the Globe revolves around the Sun.

NOTE.—This is the only Invention which produces this result in a natural way.

CALENDAR INDEX.

The Calendar Index is located in the Arm A that carries the Earth and Moon around the Sun, and it can be set in a moment by revolving the Arm, so as to point to any day of any month, or any day of the Year.

QUADRANT OF ALTITUDE.

The Quadrant of Altitude is a flexible strip of Metal graduated into equal parts, each corresponding in length to a degree on the Terrestrial Globe and bent when in use so as to closely fit its surface.

GEARING.

This Apparatus is operated by Brass and Steel *Gear-wheels*, some of which are inside of the case and some enclosed in the outer end of the Arm that carries the Earth and Moon around the Sun.

UTILITY AND ECONOMY.

The principles of Geography and the various *positions, motions and phenomena* of the Sun, Earth and Moon are expressed by this Instrument with *such precision and accuracy* that more can be learned with its use in a few lessons, than can be learned in months without it, hence its necessity in every School and Family.

THE LUNATELLUS GLOBE is manufactured by skillful Mechanics *in the most sustantial manner,* and an *exact duplicate* of any part of it may be obtained at any time, by applying to the Patentee.

That the Language of this Manual may be adapted with equal advantage to instruction in Schools and Families both North and South of the Equator; and that there may be no misapprehension, as is frequently the case in the use of terms, descriptive phrases are employed when necessary, which convey definite ideas. Instead of referring to the four Cardinal points of the Earth's orbit in the illustrations within, by their usual names Vernal Equinox, Autumnal Equinox, Summer Solstice and Winter Solstice, they are designated by the first points of the Signs where they are, and simply named Equinox and Solstice as the case may be. The Sun and Earth are at opposite Solstices at the same time and also at opposite Equinoxes at the same time, consequently they are just entering opposite Signs. On the 21st of March the Sun is at the first point of the Sign Aries which is named Vernal Equinox and from which Celestial Longitude and Right Ascension are reckoned. On the same date, 21st of March, the Earth (though at the first point of the Sign Libra) is sometimes said to be at the Vernal Equinox, as Spring in the Northern Hemisphere immediately follows. Language equally ambiguous is frequently employed in expressing the relation of the Sun and Earth to the Solstices at different Seasons of the year. Hence to avoid all uncertainty as to the points referred to in the following illustrations, they are definitely described by naming the first points of the Signs where they are.

PART I.

ILLUSTRATION I.

To Illustrate the Motions of the Sun, Earth and Moon.

See Definition 50.

It will be apparent if motion is imparted to the Arm A in the order of the Signs of the Zodiac, that the Sun's motion on his axis, the Earth's annual motion around the Sun and her daily motion on her axis, and the motions of the Moon around the Sun, around the Earth and also on her axis are in the same general direction, Eastward.

NOTE.—The order of the Signs is as follows: Aries, Taurus, Gemmini, Cancer, &c.

ILLUSTRATION II.

To Illustrate the Plane of the Ecliptic and its relation to the Plane of the Equator.

See Definitions 11, 17, 22, 23.

As the Planes of the Equator and Ecliptic cross each other in the centre of the Earth at an angle of about 23½ degrees, by placing the Semi-circle F, which is attached to the Equator of the Sun in a horizontal position, it will show the natural relation of the Plane of the Ecliptic to the Plane of the Equator as the Earth revolves around the Sun.

ILLUSTRATION III.

To Illustrate the Inclination of the Earth's Axis and its Parallelism.

See Definitions 4, 24.

As the axis of the Earth is inclined about 23½ degrees to the Plane of the Ecliptic, by revolving the Earth around the Sun it will be apparent that its natural inclination is constantly maintained and also its parallelism.

ILLUSTRATION IV.

To Illustrate the Cause of Day and Night.

See Definition 4.

The Earth being globular and opaque, the Sun enlightens constantly *that half next himself*, making *day*, while the other half which is opposite to him is in darkness, making *night*. By giving the Arm A motion, the Earth will turn on its axis and *that half* next to the Sun will be turned into the shade of the Earth which is *night*, while the *other half* which is in darkness, will be turned into the light of the Sun which is day.

NOTE.—That half of the Earth's surface on the opposite side of the Circle of Illumination C from the Sun is regarded as being in darkness.

The Circle of Illumination is the metal ring which surrounds the Globe and it represents the line around the Earth which divides day from night.

ILLUSTRATION V.

To Illustrate the Equality of Day and Night on the 21st of March or 21st of September.

See Definitions 5, 25, 30, 73, 74.

Move the Arm A till it is over the First point of the *Sign* Aries, marked Equinox *on the Base of the Instrument*, or over the First point of the *Sign* Libra, also marked Equinox, and it will be apparent from the position of the *Circle of Illumination* that each Pole is equally distant from the Sun and that the *light* of the Sun *extents to each Pole*; consequently half of the Equator and half of each of the Parallels are in the presence of the Sun and half of each is in darkness.

Now since the Earth turns with uniform motion on her axis *each half* will revolve through the same space in the *same period*, hence day and night are equal.

ILLUSTRATION VI.

To Illustrate the Cause of Long Days and Sho t Nights in the Northern Hemisphere.

See Definitions 75, 76.

Bring the Arm A to the First point of the *Sign* Capricornus (marked Solstice), and the *Circle of Illumination* will be 23½ degrees distant from each Pole dividing the Northern Hemisphere, which is inclined towards the Sun into two unequal parts, with the larger part next the Sun; hence, as the Earth turns uniformly on her axis, the cause

of Long days and Short nights in the Northern Hemisphere will be apparent.

ILLUSTRATION VII.

To Illustrate the Cause of Long Days and Short Nights in the Southern Hemisphere.

See Definition 77.

Bring the Arm A to the First point of the *Sign* Cancer (marked Solstice), and the *Circle of Illumination* will be 23½ degrees distant from each Pole dividing the Southern Hemisphere which is inclined towards the Sun into two unequal parts with the larger part next the Sun; hence as the Earth turns uniformly on her axis, the cause of long days, and short nights in the Southern Hemisphere will be apparent.

ILLUSTRATION VIII.

To Illustrate the cause of Six Months Day at the North Pole and Six Months Night at the South Pole, and vice versa.

See Definitions 5, 15.

Bring the Arm A to the First point of the *Sign* Libra (marked Equinox), and the *Circle of Illumination* C will be over the Poles. Move the Arm A in the order of the Signs, observing that the North Pole is inside towards the Sun, and the South Pole is outside of the *Circle of Illumination* away from the Sun, till the Arm A reaches the first point of the *Sign* Aries (marked Equinox) when the Cir-

cle of Illumination C will be again over the Poles. Continue the motion of the Arm A, observing that the North Pole passes outside and the South Pole passes inside the *Circle of Illumination* and remain so till the Arm A reaches the Equinox from which it started; hence as the distance which the Earth has traveled around the Sun represents one year, each pole was in alternate light and darkness for half of this period.

ILLUSTRATION IX.

To Illustrate the Cause of the Inequality in the Length of Days and Nights.

Were the Earth's axis perpendicular to the plane of the Ecliptic the Planes of the Equator and the Ecliptic would coincide, and day and night would be always equal, as the light of the Sun would constantly extend to each Pole; but the *inclination and constant parallelism of the Earth's Axis, and her annual motion,* as may be observed by giving the Globe a complete revolution around the Sun from either Equinox will show each Hemisphere to be unequally divided during each half year by the Circle of Illumination; hence the inequality of the days and nights in each Hemisphere.

ILLUSTRALION X.

To Illustrate the Rising and Setting of the Sun.

Move the Arm A in the order of the Signs and the Globe will turn Eastward on its axis, thereby causing those portions of the Globe that are in the darkness or away from

the Sun to pass under the Circle of Illumination into the presence or light of the Sun, and those portions of the Earth that are in the light of the Sun to pass under the Circle of Illumination away from the Sun into darkness.

ILLUSTRATION XI.

To Illustrate the Cause of Winter in the Northern Hemisphere and Summer in the Southern Hemisphere.

See diagram of Summer and Winter Rays on the Base B.

Bring the Arm A to the first point of the Sign Cancer (marked Solstice) and the North Pole will be inclined away from the Sun; hence his rays will be oblique and the days short in the Northern hemisphere, and in the Southern Hemisphere the Sun's rays will be more direct and the days long, making Winter in the former and Summer in the latter.

ILLUSTRATION XII.

To Illustrate Summer in the Northern Hemisphere and Winter in the Southern Hemisphere.

Bring the Arm A to the first point of the Sign Capricornus (marked Solstice) and the North Pole will be inclined towards the Sun; hence his rays will be more direct North of the Equator and the days long in the Northern Hemisphere, and in the Southern Hemisphere the Sun's rays will be oblique and the days short, making Summer in the former and Winter in the latter.

PART II.

PROBLEM I.

To Find the Longitude of a given Place.

See Definitions 48, 26, and Notes.

Count the number of degrees on the Equator of the Globe, East if the given place is East, or West if the given place is West, between the Prime Meridian and the Meridian passing through the given place and it will be the required Longitude.

EXAMPLES.

1. What is the Longitude of Ottawa?
2. What is the Longitude of Tokio?

PROBLEM II.

To Find all Places which have the same Longitude as that of a given Place.

Find the Longitude of the given place by Problem I. and under the Meridian passing through the given place will all other places be found which have the same Longitude.

EXAMPLES.

1. What is the Longitude of Montevideo?
2. Find other places having the same Longitude.
3. What is the Longitude of Quebec?
4. Find other places having the same Longitude.

PROBLEM III.

To Find the Latitude of a given Place.

See Definitions 18, 46.

Find the given place on the Globe and lay the Quadrant on the Globe with O on the Equator and its graduated edge touching the place and at right angles wi h the Equator, and the number of degrees counted on the Quadrant from the Equator to the given place will be the Latitude required.

NOTE.—For the sake of brevity the word Quadrant is used instead of the phrase "Quadrant of Altitude."

NOTE.—The Quadrant of Altitude is a flexible strip of metal graduated into equal parts, each corresponding in length to a degree on the Globe and bent when in use so as to fit its surface.

EXAMPLES.

1. What is the Latitude of St. Paul?
2. What is the Latitude of Santiago?

PROBLEM IV.

To Find all places which have the same Latitude as that of a given Place.

See Definition 30.

Find the Latitude of the given place by Problem III. and imagine a Parallel drawn through the given place, and all other places on this Parallel will have the same Latitude as that of a given place.

EXAMPLES.

1. What is the Latitude of Paramarabo?

2. Find other places having the same Latitude.
3. What is the Latitude of Bahia?
4. Find other places having the same Latitude.

PROBLEM V.

The Longitude and Latitude of any Place being given to find the Place.

See Definitions 46, 48.

Find the given degree of Longitude as in the first part of Problem I. and place the Quadrant on the Globe at right angles to the Equator, with O at the given degree of Longitude, and the required place will be found under the degree on the Quadrant corresponding to the given Latitude.

EXAMPLES.

1. Find the Point on the Globe whose Longitude is 150 degrees East and Latitude 40 degrees South.

2. Find the Point on the Globe whose Longitude is 10 degrees West and Latitude 15 degrees North.

PROBLEM VI.

Two Places being given to find their Difference of Latitude.

Find the Latitude of each place by Problem III. and if both places are on the same side of the Equator, subtract the less number of degrees of Latitude from the greater and the remainder will be the difference of Latitude; but if the Latitude of one of the places is North of

the Equator and that of the other South of the Equator, add them together and their sum will be their difference of Latitude.

EXAMPLES.

1. What is the difference of Latitude between Pittsburgh and Charleston?

2. What is the difference of Latitude between Cape Town and Cairo?

PROBLEM VII.

Two Places being given to find their Difference of Longitude.

See Definition 21, Note 3d, and Definition 26, Note 1st.

Find the Longitude of each place by Problem I. and if both places are East or both places West of the Prime Meridian, subtract the less number of degrees from the greater for the difference of Longitude; but if one place is East and the other West of the Prime Meridian, add them together and their sum if it be less than 180 degrees will be the difference of Longitude.

If the sum exceeds 180 degrees subtract it from 360 degrees for the difference of Longitude.

EXAMPLES.

1. What is the difference of Longitude between Copenhagen and Pekin?

2. What is the difference of Longitude between Madrid and Vienna?

PROBLEM VIII.

To find the Distance between two Places.

Place O of the Quadrant over one of the places on the Globe and extend it to the other, and the number of degrees between the two places will be the distance in degrees which multiplied by 60 will give the distance in Geographical miles, or multiplied by 69.1 will give the distance in Statute miles.

NOTE.—Sixty Geographical make a degree and 69.1 Statute miles make a degree.

EXAMPLES.

1. What is the distance in Geographical miles between New York and San Francisco?

2. What is the distance in Statute miles between Philadelphia and Mobile?

PROBLEM IX.

To Find Places Equally Distant from a given place.

Place O of the Quadrant on the given place as a centre of motion and move the Quadrant around this centre on the surface of the Globe, and all places over which the same degree of the Quadrant passes are equally distant from the given place.

EXAMPLES.

1. Find two places equally distant from Boston.
2. Find four places equally distant from Denver.

PROBLEM X.

The Latitude of a place, its distance and general direction from a given place being given, to find the place whose Latitude is given.

If the distance is given in miles, convert the miles into degrees; then place O of the Quadrant over the place and move the other end of it Eastward if the required place is Eastward, or Westward if the required place is Westward, till the degree marked on it representing the distance arrives at the Parallel of Latitude indicating the Latitude of the required place and this point will show the place required.

EXAMPLES.

1. Find the place whose Latitude is 40 degrees North and distant from Vera Cruz in a North-western direction 1,680 Geographical miles.

2. Find the place whose Latitude is 20 South and distant from Pernambuco in a South-western direction 2,145 Statute miles.

PROBLEM XI.

The Longitude of a place, its distance and general direction from a given place being given, to find the place whose Longitude is given.

Reduce the distance if given in miles to degrees; then place O of the Quadrant over the given place and move the other end of it Northward if the required place is

Northward, or Southward if the required place is Southward till the degrees marked on it representing the distance arrives at the given Meridian which point is the place required.

EXAMPLES.

1. Find the place whose Longitude is 90 degrees West and distant from Louisville in a South-western direction 540 Geographical miles.

2. Find the place whose Longitude is 113 degrees East and distant from Teheran in a South-eastern direction 3,550 Statute miles.

PROBLEM XII.

Any Parallel of Latitude being given to find how many miles make a degree of Longitude on it.

Place the Quadrant on the given Parallel and note the number of degrees on it between two Meridians 15 degrees apart; then multiply this number by 4 if Geographical miles are required, or by 4.6 if Statute miles are required.

NOTE.—It will be seen that if the distance between two Meridians 15 degrees apart be measured on the Equator, it will also measure 15 degrees on the Quadrant, and this number multiplied by 4 wil give 60 the number of Geographical miles in a degree, or if multiplied by 4.6 it will give 69, nearly the number of Statute miles in a degree. As we go toward the Poles, the degrees of Longitude become smaller, and wile these same Meridians will still be distant from each other 15 degrees of Longitude, the distance measured on the Quadrant, which is a uniform standard, will be less than 15 and this smaller number multiplied by the same multiplier 4 or 4.6, will give a smaller result,

i. e. fewer miles to a degree of Longitude, which is as it should be since the number of miles in a degree of Longitude decreases in exactly the same ratio as the number of degrees measured on the Quadrant.

EXAMPLES.

1. How many Geographical miles make a degree measured on a parallel 40 degrees from the Equator?

2. How many Statute miles make a degree measured on a Parallel 65 degrees from the Equator?

PART III.

ILLUSTRATION XIII.

To Illustrate the Distribution of Solar light and heat when the Earth is at either Equinox.

See Definition 5.

Bring the Arm A to either of the Equinoxes, 21st of March or 21st of September, as marked on the Base B, and observe that the Circle of Illumination stands over the Poles of the Globe and that at the Equator the rays of the Sun are direct and oblique toward the Poles; hence the Solar rays are more intense at the Equator and the temperature gradually diminishes in the direction of each Pole.

ILLUSTRATION XIV.

To Illustrate the Distribution of Solar light and Heat on the longest day in the Northern Hemisphere.

See Definition 31.

Bring the Arm A to the First Point of the Sign Capricornus (marked Solstice), 21st of June, and observe that the Circle of Illumination is 23½ degrees distant from each Pole and that the North Pole is inclined towards the Sun causing the Sun's direct rays to fall on the Northern Tropic; hence the Solar rays are most intense on the Northern Tropic and the temperature gradually diminishes as we recede from this Tropic.

ILLUSTRATION XV.

To Illustrate the Distribution of Solar light and heat on the longest day in the Southern Hemisphere.

See Definition 32.

Bring the Arm A to the First Point of the Sign Cancer (marked Solstice), 22d of December, and observe that the Circle of Illumination is 23½ degrees distant from each Pole and that the South Pole is inclined towards the Sun causing the Sun's direct rays to fall on the Southern Tropic; hence the Solar rays are most intense on the Southern Tropic and the temperature gradually diminishes as we recede from this Tropic.

ILLUSTRATION XVI.

To Illustrate the Succession of the Seasons.

As a rule the more direct the Sun's rays are on any portion of the Earth's surface the warmer it is.

Bring the Arm A to the First Point of the Sign Libra (marked Equinox), when the Sun's rays will be direct on the Equator; hence Fall in the South Temperate Zone and Spring in the North Temperate Zone.

Move the Arm A to the First Point of the Sign Capricornus (marked Solstice), when the Sun's rays will be direct on the Northern Tropic; hence Winter in the Southern Hemisphere and Summer in the Northern. Advance the Arm A to the First Point of the Sign Aries

(marked Equinox), when the Sun's rays will be direct on the Equator; hence Spring in the South Temperate Zone and Fall in the North Temperate Zone. Continue to move the Arm A till it arrives at the First Point of the Sign Cancer (marked Solstice), when the Sun's rays will be direct on the Southern Tropic; hence Summer in the Southern Hemisphere and Winter in the Northern.

ILLUSTRATION XVII.

To Illustrate the Causes which determine the width of the Zones.

See Definitions 35, 36, 37, 38, 39.

Bring the Arm A to the First Point of the Sign Capricornus (marked Solstice), and it will be apparent by moving it in the order of the Signs till it arrives at the other Solstice, that the Sun's rays were direct on every parallel between the Tropics; hence the Tropics are the limits of the Torrid Zone and are located where they are by reason of the axis of the Earth being inclined 23½ degrees to the plane of the Ecliptic, its constant parallelism and the annual revolution of the Earth around the Sun. Thus the width of the Torrid Zone is 47 degrees which is double the inclination of the Earth's axis and the distance of the Polar Circles from the Poles is 23½ degrees which equals the inclination of the Earth's axis, and the Temperate Zones are bounded by the Tropics and Polar Circles.

ILLUSTRATION XVIII.

To Illustrate Sun Time and Clock Time alternately fast and slow.

Move the Arm A till it is over the 15th of April, as marked in the Circle of Months on the Base B, and the Earth will be in the Sign Libra and the Sun will be in the Sign Aries, the opposite Sign. Revolve the Arm A once around the Sun in the order of the Signs and it may be readily seen by observing the Circle of Degrees on the Chart covering the Base B, that Sun time and Clock time are alternately Fast and Slow, and that they agree on the 15th of April, the 15th of June, the 1st of September, and the 24th of December.

ILLUSTRATION XIX.

To Illustrate the Sun's Rising North of the East Point and Setting North of the West Point during one half of the year, and his rising South of the East point and setting South of the West point during the other half of the year.

Bring the Arm A to the First Point of the *Sign* Libra (marked Equinox), and it will be apparent that while the Earth is moving in the order of the Signs to the other Equinox, that the Sun will be North of the Equator; hence he will rise North of the East Point and set North of the West Point during half of the year, and by continuing the Earth's movement around the Sun till she returns

to the Equinox where she started, it is also apparent that the Sun will be South of the Equator during an equal period; hence he will rise South of the East Point and set South of the West Point during the other half of the year.

NOTE.—The East and West Points are equally distant from the Poles of the Earth, and are on the Horizon where the Sun rises and sets when the Days and Nights are equal.

ILLUSTRATION XX.

To Illustrate the cause of the Sun's rising earlier on places East of us.

East is a relative term and in general means the direction of the rising Sun which rising results from the rotation of the Earth on its axis Eastward. To verify this fact with the Apparatus, bring the Arm A to the First Point of the Sign Aries (marked Equinox), and the *Circle of Illumination* will be over the Poles and will divide the Equator into two equal parts. Move the Arm A in the order of the Signs around the Sun and the Earth will rotate Eastward on her axis bringing into the presence of the Sun those portions of the Earth near the Eastern edge of the *Circle of Illumination* before those parts which are further West.

ILLUSTRATION XXI.

To Illustrate the cause of the apparent motion of the Sun, Moon and Stars from East to West.

Bring the Arm A to the First Point of the *Sign* Aries (marked Equinox), and if it is moved in the order of the

Signs, the Earth will also revolve Eastward on her axis, thereby producing the *apparent* Westward motion of the Sun and Moon, and of the Stars also were they properly related to the Apparatus.

ILLUSTRATION XXII.

To Illustrate the Declination of the Sun or his apparent motion North and South.

See Definition 49, Note 1st.

Bring the Arm A to the First Point of the *Sign* Cancer (marked Solstice) and the Sun's rays will be direct on the Southern Tropic. Move the Arm A in the order of the Signs and the Sun's rays will be direct successively on every Parallel till it arrives at the other Solstice when his rays will be direct on the Northern Tropic. Continue the motion of the Arm A and the Sun's rays will be direct successively on every Parallel till they are *again* direct on the Southern Tropic, thereby showing the *Declination* of the Sun North and South, which is caused by the *inclination of the Easth's axis, its constant parallelism and her annual motion around the Sun.*

ILLUSTRATION XXIII.

To Illustrate the relation of the Sun's Declination to the Circle of Illumination every day in the year.

Bring the Arm A to the First Point of the *Sign* Aries, or Libra (marked Equinox), and the Circle of Illumina-

tion will be over the Poles. Revolve the Earth around the Sun and the Circle of Illumination will recede from the Poles or approach them as the Sun recedes from the Equator or approaches it.

ILLUSTRATION XXIV.

To Illustrate the relative position of the Earth to the Sun every day of the year.

Bring the Arm A to the First Point of the *Sign* Aries (marked Equinox), and then move it in the order of the Signs till the Arm A makes one entire revolution around the Sun, and the Globe, as the Arm A is passing over each day of each month as marked in the Circle of Months on the Base B, will sustain the same relative position to the Sun in the Apparatus that the *Earth* does to the natural Sun each day of the year.

PART IV.

PROBLEM XIII.

To find at what rate per hour any given point on the Earth's surface moves, by its axial rotation.

If the given point is situated on the Equator, reduce 15 degrees to miles for the rate per hour; but if it is located between the Equator and either Pole, then find by Problem XII. the number of miles that make a degree of Longitude in the Latitude of a given point, which number multiplied by 15 will give the rate per hour.

EXAMPLES.

1. At what rate per hour do the inhabitants of Berlin move by the rotation of the Earth on its axis?

2. At what rate per hour do the inhabitants of Borneo move by the rotation of the Earth on its axis?

PROBLEM XIV.

To find the difference of time between any two places which are not under the same Meridian.

Find the difference of Longitude between the two places by Problem VII. and divide this difference in degrees by 15 and the result will be the difference of time required.

EXAMPLES.

1. Find the difference of time between Norfolk and Salt Lake City.

2. Find the difference of time between Belfast and Canton.

PROBLEM XV.

The Hour being given at any place, to determine what hour it is at any other given place.

Find the difference of time between the two places by Problem XIV. then if the place whose time is required is East of that place whose time is given, add the difference to the given time; but if the place whose time is required is West, subtract this difference from the given time and the result will be the time required.

EXAMPLES.

1. If it is 8 o'clock A. M. at Liverpool, what time is it at Hamburg?

2. If it is 11 o'clock at Naples, what time is it at Mecca?

PROBLEM XVI.

To find the Sun's place on the Ecliptic on any given day in the Year.

Find the given day in the *Circle of Months* on the Base of the Apparatus, and bring the Arm A over this day and directly under the opposite end of the Arm, will be found

the Sign and the degree of the Sun's place in the Ecliptic.

NOTE.—The Zodiac contains 12 Signs and each Sign is supposed to be divided into 30 degrees, and each degree into 60 minutes, and each minute into 60 seconds.

EXAMPLES.

1. Find the Sun's place in the Ecliptic on the 22nd of July.

2. Find the Sun's place in the Ecliptic on the 19th of February.

PROBLEM XVII.

To find the Sun's Longitude on any given day in the Year.

See Definitions 62, 70.

Find the Sun's place in the Ecliptic for the given day by Problem XVI. and directly opposite this point in the Circle of Longitude on the Base of the Apparatus, will be found the degree representing the Longitude of the Sun on the given day.

EXAMPLES.

1. Find the Sun's Longitude on the 20th of April.

2. Find the Sun's Longitude on the 20th of October.

PROBLEM XVIII.

To find the Sun's Declination and Right Ascension for any given day in the Year.

See Definition 49.

Find the Sun's Longitude for the given day by Prob-

lem XVII. and then count the same number of degrees of Longitude on the Ecliptic on the Globe in the order of the Signs from the First point of the Sign Aries to the Sun's place, and with the use of the Quadrant find the number of degrees between the Sun's place and the Equator and it will express the required Declination.

The Sun's Right Ascension is found by counting on the Equator the number of degrees, from the First point of the Sign Aries to the Meridian that passes through the Sun's place on the Ecliptic.

NOTE.—The number of degrees expressing the Sun's Declination subtracted from 90 degrees gives his Polar Distance.

EXAMPLES.

1. Find the Sun's Declination and Right Ascension on the 22nd of August.

2. Find the Sun's Declination and Right Ascension on the 20th of January.

PROBLEM XIX.

To find on what two days of the Year the Sun will be vertical at any given place within the Tropics.

See Definition 15.

Find the Latitude of the given place with the Quadrant and find with the Quadrant also, two points on the Ecliptic, on the same side of the Equator that have the same Latitude and note the Signs and degrees on the Ecliptic

where these points are; then find the Signs and degrees corresponding to them on the Base of the Apparatus and bring the short end of the Arm A, successively over these points and directly under the Arm A, in the Circle of Months on the Base, will be found the months and days required.

EXAMPLES.

1. On which two days in the Year will the Sun be vertical at Bombay?

2. On which two days in the Year will the Sun be vertical at Lima?

PROBLEM XX.

To find all places where the Sun is vertical on any given day.

Find the Sun's Declination for the given day according to Problem XVIII, and to all places on the same side of the Equator and equally distant from it, will the Sun be vertical on that day.

EXAMPLES.

1. Find the Parallel on which the Sun is vertical on the 21st of May.

2. Find the Parallel on which the Sun is vertical on the 21st of December.

PROBLEM XXI.

To find that part of the Earth where the Sun ceases to rise and that part where he ceases to set on any given day.

Move the Arm A that carries the Globe till its center is over the given day, as marked in the Circle of Months on the Base of the Apparatus, and observe the position of the Circle of Illumination near the Poles, and it will show on the Globe where the Sun has ceased to rise and also where he has ceased to set.

EXAMPLES.

1. Find those parts of the Earth where the Sun ceases to rise and set on the 21st of June.

2. Find those parts of the Earth where the Sun ceases to rise and set on the 20th of October.

PROBEM XXII.

To Illustrate a Right Sphere.

See Definitions 1, 2, 3, 51.

Move the Arm A till its center is over the word *Equinox* as marked on the Base of the Apparatus, and the plane of the Circle of Illumination which may be considered as the Horizon, will coincide with the axis of the Globe; hence the Equator, Parallels and Circles of Daily Motion are perpendicular to the Horizon.

NOTE.—Circles of Daily Motion are Circles which the heavenly bodies seem to describe in consequence of the rotation of the Earth on its axis.

EXAMPLES.

1. Where must we be located on the Earth that it may be to us a Right Sphere?

2. What would be the length of the Days and Nights on the Equator?

PROBLEM XXIII.

To Illustrate an Oblique Sphere.

See Definitions 40, 41, 42, 53.

Move the Arm A till its center is over the word *Solstice* marked on the Base of the Apparatus, and regard the Circle of Illumination as representing the Horizon, and it will be apparent that the Equator, Parallels and Circles of Daily Motion are *oblique* to the Horizon.

EXAMPLES.

1. Where must we be located on the Earth that it may be to us an Oblique Sphere?

2. If the Earth's Axis were inclined 45 degrees to the plane of her orbit, what would be the width of the Torrid Zone.

PROBLEM XXIV.

To Illustrate a Parallel Sphere.

See Definition 52.

Detach the Circle of Illumination from the Globe and pinion it again in the Equator and turn it till its plane coincides with the plane of the Equator, and it will reper-

sent the Horizon of a Parallel Sphere; hence the Equator, Parallels and Circles of Daily Motion will be Parallel to the Horizon.

EXAMPLES.

1. Where must we be located on the Earth that it may be to us a Parallel Sphere?

2. If we lived at the North Pole, in what part of the heavens wou'd the Pole Star appear?

PART V.

ILLUSTRATION XXV.

To show how the Sun and Earth are always in opposite Signs of the Zodiac.

See Definition 80.

The Zodiac being that part of the Celestial Sphere which lies about 8 degrees on each side of the plane of the Ecliptic, is divided into 12 equal parts called Signs, and these Signs have associated with them 12 Constellations. (See Chart on the Base of the Apparatus.) As the Earth enters one Sign, the Sun enters the Sign opposite, as may be seen by observing how the Sun and Earth are related to the Zodiac when motion is given to the Arm A. Presuming that the Earth has now arrived at an Equinox and that an observation of the Sun is taken from her, he would seem to be at the opposite Equinox; likewise if the Earth was at a Solstice and an observation of the Sun taken from her, he would seem to be at the opposite Solstice, which illustrates the fact that the Sun and Earth always appear to be in opposite Signs.

ILLUSTRATION XXVI.

To Illustrate the inequality of Siderial and Solar days.

The length of the Siderial day is the time that it requires the Earth to rotate once on her axis, and the length

of the Solar day is the time that elapses between two consecutive transits of the Sun over any given Meridian. To illustrate this statement bring the Arm A to the First point of the *Sign* Capricornus (marked Solstice,) and bring any Meridian of the Globe to face the Sun directly. Then give the Arm motion in the order of the Signs till the Earth rotates once on its axis, which rotation represents a Siderial day. To complete the Solar day it is necessary to revolve the Earth a little further in the same direction till the same Meridian is brought to face the Sun directly again; consequently the Solar day is 1.365 longer than the Siderial day, which is *caused* by the *annual* motion in connection with the daily motion of the Earth; hence 366 rotations of the Earth on its axis are necessary to make 365 Solar days.

ILLUSTRATION XXVII.

To Illustrate the Spring and Neap Tides.

The Spring or High Tides result mainly from the attraction of the Sun and Moon when they are on the same side of the Earth or on opposite sides; and the Neap or Low Tides result mainly from the attraction of the Sun and Moon when acting at Right Angles upon the waters of the ocean. To illustrate the Spring Tides, move the Arm A till the Moon is between the Earth and the Sun, and by referring to the Figure on the Base B you will observe where the waters are elevated most. To illustrate

the Neap Tides continue the motion of the Arm A till the Moon is in Quadrature and by referring to the adjoining Figure on the Base B, you will see how these differ from the Spring Tides and where they are on the Earth in relation to the Sun and Moon.

ILLUSTRATION XXVIII.

To Illustrate the effect of Solar and Lunar Declination on the Tides.

As the Moon is always near the plane of the Ecliptic, and as the Sun declines 23½ North, and South the same number of degrees from the Equator while the Earth is making one revolution around him, and as the tendency of the waters is to rise highest under the bodies that attract them, it will be apparent by revolving the Earth and Moon around the Sun, and observing the Declination of the Sun and Moon, that the waters of the ocean are at times as much effected by the attraction of the Sun and Moon at the Tropics as at the Equator.

ILLUSTRATION XXIX.

To Illustrate the cause of the Trade Winds.

Wind is air in motion, and the Trade Winds are winds at and in the vicinity of the Equator, which seem to be constantly blowing Westward. To illustrate their apparent westward motion, revolve the Arm A in the order of the Signs, and observe that any point on the Equator of the Globe as it turns on its axis passes through more

space in a given time, than any point in the direction of either Pole. This being the case when certain Parallels North and South of the Equator are reached, the atmosphere on the Earth keeps pace with the Earth's surface as she rotates on her axis; but in the vicinity of the Equator it does not move Eastward so fast; hence its constant *apparent Westward motion.*

ILLUSTRATION XXX.

To Illustrate the influence of the Sun in producing the Monsoons.

One of the principal causes of the Monsoons or periodic winds which blow from the Southwest for about half of the year, and from the Northeast for the other half, is the Declination of the Sun North and South.

To illustrate, give motion to the Arm A and revolve the Globe once around the Sun, observing in its passage that the Sun's rays become alternately vertical on the Northern and Southern Hemispheres as far as the Tropics. As he declines North of the Equator, regions under him are heated by his *direct* rays and the atmosphere being rarified, ascends and currents of colder air *blow* in to take its place, and as he declines South of the Equator similar results occur, which change the direction of the currents.

ILLUSTRATION XXXI.

To Illustrate the cause of Land and Sea Breezes.

Land and Sea Breezes occur daily in consequence of the heat of the Sun and daily motion of the Earth on its

axis. Islands, especially within the Tropics, are exposed during the day to the more direct rays of the Sun, as may be seen by rotating the Globe on its axis. They grow warm sooner each day than the waters which surround them, and as they grow warm the heated atmosphere ascends and the winds blow *towards* the Island to take its place. During the night the Islands *cool quicker* than the waters that surround them and the winds blow *from* them towards the the ocean.

ILLUSTRATION XXXII.

To Illustrate the Moon as always having the same side towards the Earth.

Set the Moon with the light side next to the Earth. Then give motion to the Apparatus and follow the Moon with the eye while she is making one revolution around the Earth, and it will be apparent that the same side *will continue towards* her; thus making but one rotation on her axis while she is making one revolution around the Earth.

ILLUSTRATION XXXIII.

To Illustrate the length of Lunar Days and Nights.

Give motion to the Apparatus till the Moon is between the Earth and Sun, and turn the light side of the Moon towards the Sun; then continue the motion of the Apparatus till the Moon has passed half round the Earth when she will be on the opposite side of the Earth from the

Sun, and the light side of the Moon will be turned away from the Sun, showing that each of her Hemispheres has but one day and one night during one Lunation, which is equal to about twenty-nine and one-half days.

ILLUSTRATION XXXIV.

To Illustrate the Conjunction, Quadrature, Opposition and Phases of the Moon.

Give motion to the Apparatus till the Moon is between the Sun and Earth, observing to turn the light side of the Moon towards the Sun, and she will be in *conjunction* and at her *change;* then advance the Earth in her orbit till the Moon has made a quarter of a revolution around the Earth, observing to turn the light side of the Moon towards the Sun, and she will be in *Quadrature and half-full.*

Continue the motion of the Earth in her orbit till she is between the Moon and the Sun, observing to turn the light side of the Moon towards the Sun, and it will also be towards the Earth, and the Moon will then be in *opposition* and *full.* Again advance the Earth in her orbit till the Moon makes another quarter of a revolution around the Earth, observing to turn the light side of the Moon towards the Sun, and she will be entering upon her *fourth quarter* and again *half-full;* hence you will observe that when she reaches the end of this quarter she will be again at her *change.*

Note.—If the Earth and Moon were at their relative distances in the Apparatus, the Moon would not appear IN A DIRECT LINE with the Earth and Sun, except when she would be at or near one of her Nodes.

ILLUSTRATION XXXV.

To Illustrate the Eccentricity of the Moons Orbit.

Give motion to the Apparatus and the Moon may be seen moving around the Earth, and alternately approaching and receding from the Earth, while passing around it.

ILLUSTRATION XXXVI.

To Illustrate the relation of the Plane of the Moons Orbit to the Plane of the Ecliptic.

The plane of the Moons Orbit is at an Angle of about 5 degrees with the plane of the Ecliptic, crossing the plane of the Ecliptic at two opposite points called Nodes. To illustrate this relation, give motion to the Apparatus and the Moon may be seen rising and falling alternately above and below the plane of the Ecliptic, which plane is represented by the Semi-circle F attached to the Equator of the Sun.

ILLUSTRATION XXXVII.

To Illustrate the Siderial and Synodical revolutions of the Moon.

See Definition 80.

Give motion to the Apparatus till the Sun, Earth and Moon are in conjunction, with the Moon between the Sun and Earth. Then move the Arm A in the order of the Signs till the Moon has passed exactly once around the Earth and she will have made a Siderial revolution; and by advancing the Arm A in the same direction till the

Sun, Moon and Earth are again in conjunction, the Moon will have made a Synodical revolution.

NOTE.—In consequence of the Annual motion of the Earth, the Siderial revolution of the Moon is about TWO DAYS less than her Synodical revolution, the length of the former being about 27⅓ days and that of the latter about 29½ days.

ILLUSTRATION XXXVIII.

To Illustrate Solar and Lunar Eclipses.

When the Moon passes between us and the Sun, she cuts off some or all of his light, hence a Solar Eclipse; and when the Earth comes between the Sun and Moon, some or all of her light is cut off, hence a Lunar Eclipse. To illustrate Solar and Lunar Eclipses with the Apparatus, give it motion and observe the course of the Moon as she passes between the Sun and Earth *eclipsing the Sun*, and also as the Earth intervenes between the Sun and Moon *eclipsing the Moon*.

NOTE.—From observing the course of the Moon around the Earth in the Apparatus, it might be inferred that there is a Solar and a Lunar Eclipse every revolution of the Moon around the Earth, but if we consider the Earth and Moon to assume their proper relative distances from the Sun and each other, and that the orbit of the Moon crosses the plane of the orbit of the Earth, at an angle of about 5 degrees and that the crossing points are slowly changing their places around the Earth, it becomes apparent that the Moon will be generally so far North or so far South of the plane of the Ecliptic, that her shadow will not obscure the light of the Sun, neither the Earth's shadow obscure her light. Eclipses of the Sun and Moon can only occur when the Moon is at or near a Node and is in a line with the Sun and Earth.

DEFINITIONS AND EXPLANATIONS.

The Earth on which we dwell is the third primary planet of the eight that revolve around the Sun. Her mean distance from the Sun is about 91,430,000 miles and she revolves once around him in about 365¼ days, and rotates once on her axis in about 24 hours. The distance through her center from North to South, which is her Polar diameter, is about 7,899 miles, and the *mean* distance from any point of her Equator to the opposite point, which is her Equatorial diameter, is about 7,926 miles. In consequence of the difference of about 26½ miles in the lengths of these diameters, she is not a sphere, but an Oblate Spheroid, which means a sphere flattened on the opposite sides. *

1. A SPHERE is a solid or volume bounded by a surface, every point of which is equally distant from a point within, called the center.

2. THE RADIUS OF A SPHERE is a straight line drawn from the center to any point in the surface.

3. THE DIAMETER OF A SPHERE is a straight line drawn through its center and each end terminating in its surface.

* NOTE.—The earth's equatorial circumference is an ellipse whose major axis is 1⅔ miles longer than its minor axis.

4. THE AXIS OF THE EARTH is the diameter on which it turns once in about 24 hours, and the same imaginary line continued North and South until it meets the starry heavens constitutes the axis of the Celestial Sphere.

5. THE POLES OF THE EARTH are the extremities of the Earth's axis, and the POLES OF THE HEAVENS are the extremities of the Celestial axis.

6. A CIRCLE is a plane surface bounded by a curved line, every point of which is equally distant from a point within, called the center. *

7. THE CIRCUMFERENCE OF A CIRCLE is the line that bounds the circle.

8. THE RADIUS OF A CIRCLE is any straight line drawn from its center to its circumference.

9. THE DIAMETER OF A CIRCLE is any straight line passing through its center and each end terminating in its circumference.

10. AN ARC is any part of a circumference.

11. A PLANE is a surface such that if any two points be taken in it, a straight line joining these points will be wholly in the surface.

12. A CURVED SURFACE is a surface which is neither a plane nor composed of planes.

* NOTE.—The word CIRCLE, is used instead of circumference in describing lines on the surface of the globe.

NOTE.—The phrase, PLANE OF THE CIRCLE, is used to denote the CIRCLE proper.

13. A STRAIGHT LINE is one that does not change its direction at any point.

14. A CURVED LINE is one that changes its direction at every point.

15. A POINT is that which has position, but not magnitude.

16. PARALLEL LINES are such as have the same direction, and are therefore equally distant from each other at all corresponding points.

17. AN ANGLE is the opening or difference in direction between two lines which meet in a common point called the vertex.

18. A RIGHT ANGLE is one that is equal to 90 degrees and is the angle which may be formed by drawing a vertical and a horizontal radius in a circle.

19. AN ACUTE ANGLE is one that is less than a Right angle.

20. AN OBTUSE ANGLE is one that is greater than a Right angle. *

21. A GREAT CIRCLE is one which passes through the center of a Sphere and divides it into two equal parts. †

* NOTE.—OBLIQUE ANGLES, embrace the two proceding classes, Obtuse and Acute.

† NOTE.—For the sake of convenience, both the Earth and the Heavens are conceived to be marked by Points and divided into parts by Lines and Circles, whose Planes cut through them in various directions.

NOTE.—Every Circle, great or small is conceived to be divided into 360 equal parts called degrees, therefore a degree is not a fixed quantity, but only an aliquot part of any Citcle.

22. THE EQUATOR is a great Circle which cuts the Earth at Right angles with its Axis, and divides it into the Northern and Southern Hemispheres.

NOTE.—The intersection of the PLANE of the Equator with the surface of the Earth, constitutes the Terrestrial Equator, and with the concave Sphere of the Heavens the Celestial Equator or the Equinoctial.

23. THE ECLIPTIC, is a great Circle in which the Earth performs her annual revolution around the Sun, and also in which is the apparent path of the Sun.

NOTE.—The Orbit of the Earth, is her pathway in the Ecliptic.

24. THE OBLIQUITY OF THE ECLIPTIC is the inclination of the Ecliptic to the Equinoctial of about $23\frac{1}{2}$ degrees.

25. THE EQUINOCTIAL POINTS are the intersections of the Ecliptic and Eqninoctial.

NOTE.—In consequence mainly of the Solar and Lunar attraction upon the excess of matter around the Equator of the Earth, it is slightly disturbed in its yearly motion, causing the intersections of the Ecliptic with the Equinoctial to move westward about 50″ annually.

26. MERIDIANS are great Circles, which pass through the North and South points, and cross the Equator at Right angles.

NOTE.—THE FIRST OR PRIME MERIDIAN, is the Meridian from which Longitude is reckoned East or West. Longitude is sometimes reckoned from the Meridians of Ferro, Paris, Madrid and Washington, but usually from the Meridian of Greenwich, England.

NOTE.—The word Meridian frequently denotes the upper half of a great Circle, which passes through the North and South points.

NOTE.—Meridians are sometimes called Hour Circles, and also lines of Longitude, because the Arcs of the Equator intercepted between them, are used as measures of Time and Longitude.

27. The Equinoctial Colure is the Meridian which passes through the Equinoctial points.

28. The Solstitial Colure is the Meridian which passes through the Solstitial points.

The Solstitial Points are the points where the Ecliptic touches the Northern and Southern Tropics.

Noe.—The East and West points are equidistant from the Poles of the Earth, and are where the Sun rises and sets when the Days and Nights are equal.

29. A Small Circle is one that divides a Sphere into two unequal parts, as it does not pass through the centre of the Sphere.

30. Parallels of Latitude are small Circles, parallel to the Equator, and when extented into the Heavens, are called Parallels of Declination.

31. The Tropic of Cancer is the Parallel of Latitude which touches the Northern point of the Ecliptic called the Summer Solstice.

32. The Tropic of Capricorn is the Parallel of Latitude which touches the Southern point of the Ecliptic called the Winter Solstice.

32. The Arctic or North Polar Circle is the Parallel of Latitude which passes through the Pole of the Ecliptic, distant about 23½ degrees from the North Pole.

34. The Antarctic or South Polar Circle is the parallel of latitude which passes through the Pole of the Ecliptic, distant about 23½ degrees from the South Pole.

35. Torrid Zone, is that portion of the Earth's surface which lies between the Tropics.

36. The North Temperate Zone is that portion of the Earth's surface which lies between the Tropic of Cancer and the Arctic Circle.

37. The South Temperate Zone, is that portion of the Earth's surface which lies between the Tropic of Capricorn and the Antarctic Circle.

38. The North Frigid Zone is that portion of the Earth's surface which lies North of the Arctic Circle.

39. The South Frigid Zone is that portion of the Earth' surface which lies South of the Antarctic Circle.

40. The Sensible Horizon is a Circle touching the Earth at the spectators feet and extending to the Heavens.

41. The Visible Horizon is the line where the Sky and Earth seem to meet, forming a Circle around the spectator.

42. The Rational Horizon is a Great circle which is parallel to the Sensible Horizon and distant from it nearly 4.000 miles, the semi-diameter of the Earth, and divides the Earth into upper and lower Hemispheres and separates the visible Heavens from the invisible.

Note.—In consequence of the vast distance to the Starry Sphere, these Horizons seem to coincide in it, so that we see the same Hemisphere of stars that we would see if the upper half of the Earth were removed and we were standing on the Rational Horizon.

Note.—Every place on the Earth has its own Horizon.

43. Refraction of Light is the deflection of the rays from their original course, by the medium through which they pass.

44. The Cardinal Points when referred to the Earth are North, South, East and West, when referred to the Heavens are the Zenith and Nadir, and when referred to Ecliptic, they are the Equinoxes and Solstices.

45. The Mariners Compass is composed of a Magnetic Needle, free to move on a sharp-pointed support erected in the centre of a Dial which is divided into thirty two equal parts representing the Cardinal and Intermediate points of the Horizon.

46. The Latitude of a place on the Earth is its distance measured on its Meridian North or South from the Equator.

47. The Polar distance of a place on the Earth is its distance measured on its Meridian from the nearest Pole.

Note.—Latitude and Polar distance are mutually complements of each other, as each is measured on the same Meridian, in opposite directions, just 90 degrees.

48. Longitude is distance measured on the Equator or a Parallel from some Standard Meridian, called the First or Prime Meridian, East or West, from 0 to 180 degrees.

49. RIGHT ASCENSION is distance Eastward from the First Point of the Sign Aries, measured on the Equinoctial from 0 to 360 degrees.

NOTE.—The Declination of a heavenly body, is its distance North or South from the Equinoctial.

NOTE.—DECLINATION corresponds to Terrestrial Latitude.

NOTE.—The Polar distance of a Star, is the complement of its Declination.

50. The Zodiac is that part of the Celestial Sphere which lies about 8 degrees on each side of the Ecliptic.

51. A RIGHT SPHERE is one whose Axis lies wholly in the Plane of the Horizon, hence the Equator, Parallels and Circles of daily motion, are perpendicular to the Horizon.

52. A PARALLEL SPHERE is one whose Axis is perpendicular to the Plane of the Horizon, hence the Equator coincides with the Horizon, and the Parallels and Circles of a daily motion, are Parallel with the Horizon.

53. AN OBLIQUE SPHERE is one whose Axis is oblique to the Horizon, hence the Equator, Parallels and Circles of daily motion, are oblique to the Horizon.

Note.—The definitions of the different Points, Lines and Circles which are used in Astronomy, and the propositions based upon them, compose the DOCTRINE OF THE SPHERE.

54. THE POLES OF THE HORIZON are the Zenith and Nadir.

55. THE ZENITH is that point in the Celestial Sphere, directly over the observers head.

56. THE NADIR is that point in the Celestial Sphere, directly under our feet.

57. A VERTICAL CIRCLE is one that passes through the Zenith and Nadir and is perpendicular to the plane of the Horizon.

58. THE ALTITUDE OF A HEAVENLY BODY is its elevation above the Horizon, measured on a vertical circle.

59. THE ZENITH DISTANCE OF A HEAVENLY BODY is the complement of its altitude, that is the difference between the altitude and 90 degrees.

60. THE AZIMUTH OF A HEAVENLY BODY is the angular distance between the plane of the Meridian and that of a vertical circle passing through the body, and both passing through the Zenith.

NOTE.—Azimuth is reckoned on the Horizon East or West from the North and South points, from 0 to 90 degrees.

61. THE AMPLITUDE OF A HEAVENLY BODY is the angular distance from the Prime Vertical to a vertical circle passing through the body.

NOTE.—Amplitude is reckoned on the Horizon North or South from the Prime Vertical, from 0 to 90 degrees.

NOTE.—Azimuth and Amplitude are mutually complements of each other, as each is measured on the same great circle in opposite directions just 90 degrees.

62. CELESTIAL LONGITUDE is angular distance East from the first point of the Sign Aries, measured on the Ecliptic from 0 to 360 degrees.

63. CELESTIAL LATITUDE is angular distance measured on a Secondary from the Ecliptic, from 0 to 90 degrees.

64.—THE AXIS OF A GREAT CIRCLE is a straight line passing through its center at Right Angles to its Plane.

65. THE POLE OF A GREAT CIRCLE is the Point where its Axis cuts through the surface of the Sphere.

66. EVERY GREAT CIRCLE has two Poles, each of which is 90 degrees from the Great Circle.

NOTE.—A GREAT CIRCLE which passes through the Pole of another Great Circle, cuts the latter at Right Angles and is called a SECONDARY to that Circle.

NOTE.—MERIDIANS are Secondaries to the Equator.

67. PERIHELION is that point in the Earth's Orbit nearest the Sun.

68. APHELION is that point in the Earth's Orbit farthest from the Sun.

69. THE LINE OF THE APSIDES is the line joining the Perihelion and Aphelion points.

70. ANGULAR DISTANCE is the difference in direction between two points as seen from a third point.

71. ANGULAR MOTION is the motion of a point or body around another point which is at rest.

72. ANGULAR VELOCITY is the rate of angular motion.

NOTE.—We ascertain the position of a given place on the Globe or in the Heavens, by taking its angular distance from two Great Circles, the Horizon and the Meridian, or the Horizon and the Prime Vertical, they being Coordinate Circles are used for such measurements.

73. THE AUTUMNAL EQUINOX is the time when the Sun crosses the Equator in going Southward, which occurs about the 22d of September.

74. THE VERNAL EQUINOX is the time when the Sun crosses the Equator in returning Northward, which occurs about the 21st of March.

75. THE SOLSTITIAL POINTS are the two points of the Ecliptic most distant from the Equinoctial.

76. THE SUMMER SOLSTICE is the time when the Sun is at his greatest distance North of the Equinoctial, which occurs about the 21st of June.

77. THE WINTER SOLSTICE is the time when the Sun is at his greatest distance South of the Equinoctial, which occurs about the 22d of December.

78. THE CIRCLE OF PERPETUAL APPARITION is the boundary of that space in the Heavens around the elevated Pole in which the Stars never set.

79. THE CIRCLE OF PERPETUAL OCCULTATION is the boundary of that space in the Heavens around the depressed Pole in which the Stars never rise.

SIGNS AND CONSTELLATIONS OF THE ZODIAC.

80. The Ecliptic is divided into 12 equal arcs of 30 degrees each, called Signs, and beginning at the Vernal Equinox they succeed each other Eastward in the follow- order: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, Pisces.

These 12 arcs of the Ecliptic are supposed to have corresponded about 2,200 years ago, with 12 constellations having the same names. But in consequence of

the retrograde motion of the Equinoc Points, the *Signs* of the Ecliptic have left the constellations with which they were formerly associated. As their motion corresponds with that of the Equinoctial Points, they have moved Westward about one whole Sign in the period referred to, so that the division of the Ecliptic called Aries lies in the constellation Pisces and the Sign Taurus in the constellation Aries and the Sign Gemini in the constellation Taurus, &c. Hence at the present time the names of the *constellations* of the Zodiac, North of the Equinoctial, commencing at the Vernal Equinox, are Pisces, Aries, Taurus, Gemini, Cancer, Leo and continuing in the same order, those South of the same Great Circle, are Virgo, Libra, Scorpio, Sagittarius, Capricornus and Aquarius.—See Chart on the Base of the Lunatellus Globe.

Letters representing the principal parts of the Star Globe.

T. The Tripod. I. The Hour Index. S. The Spiral Springs.
M. The Meridian. P. The Polar Bearings.
B. The Meridian Bearing. Q. The Quadrant.
H. The Horizon. G. The Globe.

Directions for putting the parts together.

1st. Insert the shaft of the Meridian Bearing B, in the socket of the shaft of the Tripod T, and turn the screw in the Tripod till it comes in contact with the shaft of the Meridian Bearing B.

2nd. Drop one of the two Spiral wire-springs S, into each end of the tubular axis of the Globe and put the Hour Index marked South on the South Pole, and the one marked North on the North Pole, and follow the Spiral wire-springs into the ends of the tubular axis of the Globe, with the shafts of the Polar Bearings P.

3rd. Place the groove in the outer end of one of these Bearings, on the inside of the Meridian M, and remove the small plate on the end of the other Polar Bearing, with a small screw driver, (taking care not to lose the very small rollers through which the screws pass.) and press the Polar Bearing towards the center of the Globe till it takes its place on the inside of the Meridian M, and then replace the small plate which was removed from the Polar Bearing, and the Globe is ready for use.

STAR GLOBE.

STAR GLOBE.

(Diameter 12 inches.)

The Star Globe, being complete in all its appointments, contains elements of UTILITY and DURABILITY which are not found in any other. Unlike many others, that are now being made without a Graduated Meridian, or Hour Indices, or Quadrant of Altitude, or Horizon, it possesses all of these parts, and all others which are essential either for convenience or instruction.

GLOBE STAND.

The Globe is mounted on a metallic Tripod, which is light, substantial, convenient, neatly japanned, and tastefully ornamented.

MERIDIAN.

The Meridian which contains the Globe is brass, plated with nickel, and GRADUATED ON BOTH SIDES. One-fourth of its circumference is inserted in a concave metallic bearing to give it permanence, which bearing is united with the central shaft of the Tripod by a swivel, so that it will revolve horizontally, without changing the position of the Tripod.

HORIZON.

The Horizon is also composed of metal, and it is so fitted to the Meridian at its horizontal diameter, THAT IT MAY BE CONVENIENTLY REMOVED AND REPLACED. Upon it is a Map containing the Signs of the Ecliptic and their divisions

into degrees, the Months of the Year and their divisions into Days, the Cardinal and Minor Points of the Compass and the degrees of Azimuth and Amplitude.

THE GLOBE.

The Globe itself *which is twelve inches in diameter*, is constructed of materials that are tough, light, durable and not perceptibly effected by any climatic changes of temperature. It is skillfully made, which in conjunction with the strength of the materials of which it is composed, renders its surface proof against change of form unless improperly used.

GLOBE MAP.

The Geographical Map with which this Globe is covered is issued by the Map Publishing House of W. & A. K. Johnston, Edinburgh, Scotland, and this is a sufficient guarantee that it has no superior. It is engraved in copper and printed in colors, and contains the Ocean Currents, the Isochimal and Isothermal lines, the latest Political Divisions and Boundaries of all Countries, the corrected Boundaries of the States and Territories of the United States, the Topography of various places and Countries as reported by modern Explorers, together with much new matter which is the outgrowth of both National and International enterprise. This array of additional knowledge, combined with that which the Map originally contained, gives to the Globe which it covers a value which many others do not possess.

GLOBE MOVEMENT.

The Axis of the Globe, unlike all others, is made of metal tubing, and in its ends are placed springs and bearings on which it revolves. The outer ends of these bearings are grooved so as to receive the inner edge of the Meridian, and they move on it when a change in the position of the axis of the Globe is desired, *a novel and very convenient device for this purpose.*

HOUR INDICES.

The Hour Indices, which are placed around the Poles of the Globe are stamped out of sheet brass and nickel-plated. Each Index is divided into twenty-four equal parts, and these parts have associated with them characters that represent the hours of the day.

QUADRANT OF ALTITUDE.

The Quadrant of Altitude is a flexible strip of metal graduated into equal parts, each corresponding in length to a degree on the Globe, and bent when in use so as to closely fit its surface.

THE ANALEMMA.

The Analemma on the Globe is a diagram which extends across the Torrid Zone. It contains the days of each month in the year, so arranged, that if the month and day of the month are given, the Declination of the Sun at that time may be readily found, or if the Declination of the Sun is given, the month and day of the month may be readily found, and

the Sign and the degree of the Ecliptic in which he is, also, the Equation of time, or the difference between Sun and Clock time for any day of the year.

THE STAR GLOBE is manufactured by Skillful Mechanics IN THE MOST SUBSTANTIAL MANNER, and an EXACT DUPLICATE of any part of it can be obtained at any time by applying to the Patentee.

A MANUAL containing a comprehensive series of Problems, Examples and Illustrations will accompany each Globe.

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